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COMMITTEE ON THE PEACEFUL USES
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Agenda item 7

USE OF NUCLEAR POWER SOURCES IN SPACE

Working paper submitted by the United States of America

As this Subcommittee continues to work towards finalizing deliberations on the use of nuclear power sources (NPS) in outer space, and as the Legal Subcommittee moves towards consensus on a full set of draft principles on NPS, the United States believes that it is incumbent on both Subcommittees to ensure that any complete set of recommendations or draft principles is as credible as possible in the light of current technical understanding.

In the United States' view, it is also of the utmost importance to ensure that consensus recommendations, as they have been reached in this Subcommittee, or draft principles, as discussed in the Legal Subcommittee, fully reflect the understanding of the participants in those discussions on those recommendations or draft principles. With these objectives in mind, the United States wishes to review significant aspects of its NPS activities as they relate to the implementation of safety principles. We also wish to state clearly, for the record, the United States' interpretation of certain provisions now contained in the draft principles. Finally, we wish to propose and explain certain changes to the language of the principles which we believe will enhance their value.

This is offered not only only to deepen Member States' understanding of space nuclear power generally, and United States practice in particular, but also to continue constructive progress towards a set of final recommendations in this Subcommittee and, ultimately, a set of final principles in the Legal Subcommittee on NPS.

United States NPS activities

The United States continues to believe that space nuclear power has an important role in the use and exploration of outer space. Historically, the United States has followed the practice of employing stringent design and operational flight safety measures to protect the public and the environment under normal operations and postulated accident conditions. In addition, as NPS are considered for use in particular missions, they undergo intensive, open and publicly available safety analyses to establish the potential risks under credible operational or accidental circumstances.

The United States environmental review process is conducted in compliance with the National Environmental Policy Act of 1969. As mandated by that law, the environmental consequences of selecting an NPS (over a non-nuclear power source), as well as engineering, economic and safety considerations, are weighed before final launch approval. The Act requires consideration of a broad range of topics, including potential environmental, socio-economic and cultural impacts as they may pertain to humans, flora and fauna. The environmental impact evaluation process includes formal opportunities for input by the general public and has evolved into a significant and effective method of informing the public about proposed NPS launches and any environmental consequences thereof.

Each United States agency involved in the use of NPS in space has its own regulations that are based on overall Federal regulations regarding exposure to nuclear radiation. The United States practice is one of developing detailed criteria, specifications and requirements for agency use in a top-down approach, beginning with overall Federal regulations and guidance. Furthermore, the emphasis is on line management responsibility for safety with independent oversight at the various levels of line management. Safety is a principal driver in the design of the nuclear heat source in an NPS for use in outer space.

Finally, there is an overall nuclear safety review conducted by an independent inter-agency nuclear safety review panel (INSRP) prior to the proposed launch of an NPS. The INSRP works under a presidential directive and agency guidelines to conduct a safety review for each planned mission. The panel does not make a recommendation of launch approval or disapproval. Rather, it provides an independent evaluation of radiological risk to the decision-makers who must weigh the benefits of the mission against the potential risks. Panel members review safety analysis reports, as they are prepared by the Department of Energy, for information such as impacts on human health and safety as well as other sources of pertinent information. The panel prepares a safety evaluation report containing an independent assessment of launch and flight risks, which is then submitted to the Executive office of the President, as part of the request for nuclear safety launch approval.

The primary safety design objective for both radioisotope and reactor power sources is to minimize the potential interaction of the radioactive materials with the public and the environment. In the case of radioisotope thermoelectric generators (RTGs), this objective leads to a design philosophy of containment, immobilization and recovery of the nuclear materials.

As in the case of RTGs, safety has been the principal driver in the design of the SP-100 reactor power assembly under development in the United States. Consistent with overall United States safety criteria, this reactor is designed to prevent inadvertent criticality during handling or in postulated accident conditions. The keys to SP-100 safety may be summarized as follows:

- The reactor will be launched "cold" (i.e., no significant radioactive fission products and non-operation);
- The reactor is designed to prevent accidental start-up during launch and ascent;
- The reactor is started only after achieving the safe operating orbit;
- The reactor is designed to prevent inadvertent criticality through the use of two independent reactor shut-down systems;
- The reactor is designed to remain in, or be boosted to, high Earth orbit after operation;
- Even though the reactor is designed to remain permanently in space, it has been designed to safely accommodate postulated accidental re-entries and impact.

United States views and recommendations relating to NPS

Since the beginning of the Subcommittee's deliberations on NPS, the United States has been supportive of the Subcommittee's work on clarifying the scientific and technical aspects of the safe use of NPS in outer space. Indeed, we are hopeful that the work in this Subcommittee can lay a solid technical foundation for consideration of principles in the Legal Subcommittee. In this regard, the United States believes that the Subcommittee has an obligation to ensure that consensus recommendations are both scientifically and technically sound. Only in this way can this Subcommittee's work find its fullest meaning in final principles.

In the United States' view, the Subcommittee should not retreat from the difficult task of ensuring that the highest scientific and technical standards are met in every one of the recommendations developed. Rather, we should welcome the opportunity. Ultimately, any principles based on our recommendations will only be as strong as the recommendations themselves.

It is in this spirit that the United States proposes to revisit certain specific portions of the Subcommittee's recommendations underlying what is now termed principle 3 in the Legal Subcommittee. It is our objective to enhance their technical credibility.

Some of the recommendations proposed here would not require any changes to the language adopted in the report of the Scientific and Technical Subcommittee's 1990 Working Group on NPS (A/AC.105/456, annex III). There are other recommendations

which we believe should be adopted but which will involve changes in the language adopted in the report of the Subcommittee's 1990 Working Group on NPS and draft principle 3.

Regarding the opening paragraph to principle 3, we believe that it is appropriate for all the principles to stress that the use of nuclear power sources should be based on technical needs with full consideration of safety and environmental concerns. It is, however, incongruous for one principle to have its own preamble. We propose deleting the paragraph and having an appropriate statement on this idea in an overall preamble. We will suggest specific language in time for the next Legal Subcommittee meeting.

Throughout the recommendations, "shall" and "must" should be replaced with "should". In our view, this is clearly consistent with the non-binding, recommendatory nature of the principles.

We would also recommend that another clarification be made throughout the text, replacing the word "foreseeable" with the word "credible". The United States safety assessments which cleared the Ulysses and Galileo spacecraft for launch limited the universe of hypothetical accident scenarios to those with reasonable probability of occurrence. This set of scenarios was thus labelled as "credible". The United States change brings the usage in the recommendations into conformity with this established formulation.

The United States proposes that the concept of dose limits be re-examined and recommends that paragraph 1.3 of the 1990 NPS Working Group's recommendations (A/AC.105/456, annex III, sect. III, para. 15) be modified. We recommend substituting the following language for the current second and third subparagraphs:

> "Except in cases of low probability accidents with potentially serious radiological consequences, the design for the NPS systems <u>should</u> [shall], with a high degree of confidence, restrict radiation exposure to a limited geographical region and to individuals <u>in the public to risks (probability of exposure times consequence) which are as low as reasonably achievable</u>."

In the United States' view, this modification, by taking into account the probabilistic concept of risk, which is a central feature of a thorough safety assessment, relates the recommendation directly to the well-proven space NPS practices of the United States.

A similar type of clarification is recommended for the first two sentences of part 1.4, to read:

> "Systems important for safety <u>should</u> [shall] be designed, constructed and operated in accordance with the general concept of defence-in-depth, <u>as appropriately adapted for space nuclear systems</u>. Pursuant to this concept, <u>credible</u> [foreseeable] safety-related failures or malfunctions must be <u>compensated for by design or</u> capable of being corrected or counteracted by an action or a procedure, possibly automatic".

We believe that this clarification removes any doubts as to the intent behind the application of the term "defence-in-depth". Without this clarification, the paragraph could be read to apply to space systems, a terrestrial nuclear term of art that embodies design approaches which may be technically unfeasible in space. We are convinced that the Subcommittee did not, in its earlier recommendations, intend to apply the terrestrial standards as such to space systems. The second sentence of part 1.4, as it now appears, makes no provision for passive systems, such as RTGs, or for the preferred solution, in the case of either passive or active systems, of countering risks by system or mission design. The refinement proposed by the United States contributes materially to the completeness of the paragraph.

Related to the proposed modifications to the reference to "defence-in-depth", the United States believes that the current use of "inter alia" in subparagraph 3 of 1.4 should be clearly understood. We note that in subparagraph 1 of 1.4 in A/AC.105/456, annex II, section III, the term "for example" precedes the recommendation that successive barriers are considered. It is our view that, in subparagraph 3 of 1.4 in A/AC.105/456, annex III, section III, as well as in paragraph 1.4 of principle 3 as it appears in annex I to the 1990 report of the Legal Subcommittee (A/AC.105/457, annex I, para. 12), "inter alia" should be replaced with "for example". It is our view that there need not necessarily be other means of ensuring reliability beyond those listed in the remainder of the sentence, or that any or all of those listed must be employed in a given NPS. The United States expressed this view in joining consensus on principle 3 in the Legal Subcommittee and wishes to reconfirm that view here.

The United States believes the Subcommittee's intent in paragraph 2.4 was that NPS would not be operated at power for sustained periods of time so as to generate a meaningful radionuclide inventory. Zero power critical testing is an important part of launch safety that does not produce significant radionuclides. Without such testing, NPS would be less safe. Therefore, the following language is suggested for paragraph 2.4.

> "Nuclear reactors should [shall] not be made critical during or after launch until [before] they have reached their operating orbit or [interplanetary] trajectory."

Finally, the last clarification we would recommend involves paragraph 3.2 of A/AC.105/456, annex III, section III, which also appears as paragraph 3.2 in annex I to the 1990 report of the Legal Subcommittee (A/AC.105/456, annex I, para. 12). The United States believes that the paragraph should read

> "Except for low probability occurrences, the nuclear fuel in radioisotope generators should [shall] be protected by a containment system that is designed and constructed to withstand the heat and aerodynamic forces of re-entry in the upper atmosphere under credible [foreseeable] orbital conditions [including highly elliptical or hyperbolic orbits where relevant]. Upon impact, the containment system and the physical form of the isotope should [shall] ensure that any radioactive material scattered into the environment is localized, so that the impact area can be [completely] cleared of radioactivity by a recovery operation."

The first change is intended to take into account the fact that the probability of accidental re-entry from hyperbolic or highly elliptical orbit can be reduced to a very low value by mission design and operations. The change in the last sentence is in recognition of the fact that the practical design objective for RTG containent systems is localization rather than zero release under all circumstances, and that there are practical limits from a cost-versus-risk standpoint on "complete" clearing of radioactivity by a recovery operation.

Summary

The United States wishes to emphasize that these proposed clarifications and modifications to the Subcommittee's recommendations are offered in a constructive spirit. We are seeking to contribute further to the substantial progress made in the Committee on NPS. We view these proposed refinements as steps towards a meaningful set of recommendations that are based on sound scientific and technical findings. Ultimately, any principles adopted on the basis of this Subcommittee's recommendations will only be as strong as the scientific and technical merit behind them. It is with this in mind that we respectfully submit these remarks for the Subcommittee's consideration and for delegations' comments.